Public Economics: Tax & Transfer Policies

(Master PPD & APE, Paris School of Economics)

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Lecture 3: Externalities & corrective taxation: illustration with global warming & carbon taxes

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(check on line for updated versions)

Basic theoretical model and optimal tax formulas with externalities: $U(c,e,E)$

- Continuum of agents i in [0;1]
- Two goods: non-energy good c and energy good e

- Identical utility function:

$$U_i = U(c_i,e_i,E) = (1-\alpha)\log(c_i) + \alpha\log(e_i) - \lambda\log(E)$$

With: c_i = individual non-energy consumption (food, clothes, i-phones, etc.)

e_i = individual energy consumption (oil, gaz, etc.)

$E = \int e_i \, di$ = aggregate world energy consumption = negative externality (e.g. due to carbon emissions, global warming)

→ utility increases with e_i but decreases with E: everybody wants energy for himself but would like others not to pollute too much

- Simple linear production function (full substitutability): everybody supplies one unit of labor $l_i=1$, and labor can be used to produce linearly c or e with productivity = 1
- Aggregate budget constraint: $C + E = Y = L = 1$
- This is like assuming a fixed relative price of energy
- Alternatively, one could assume concave production functions: $Y_c = F(L_c), Y_e = G(L_e)$, $Y = Y_c + p\ Y_e$,
with p = relative price of energy = increasing with energy demand; one could also introduction K, etc.

- **Laissez-faire equilibrium**:
- Max $U(c_i,e_i,E)$ under $c_i+e_i<y_i=l_i=1$

  → $c_i = (1-\alpha)y_i$ & $e_i = \alpha y_i$ → $C= 1-\alpha$ & $E = \alpha$

(first-order condition: Max $(1-\alpha)\log(1-e_i)+\alpha\log(e_i)$

→ $(1-\alpha)/(1-e_i)=\alpha/e_i$) → $e_i=\alpha$)

- Say, α = 20% & $1-\alpha$=80% : in the absence of corrective taxation, we spend 20% of our ressources on energy (20% of the workforce works in the energy sector, etc.)
- **Private agents do not internalize externalities**: they choose energy consumption independently of λ (even if λ very large!)

- **Social optimum**:
- Max $U(C,E,E)$ under $C+E<Y=1$

I.e. same maximization programme as before, except that the social planner internalizes the fact that $E = \int e_i \, di$: so the first-order condition becomes

Max $(1-\alpha)\log(1-E)+(\alpha-\lambda)\log(E) \rightarrow (1-\alpha)/(1-E)=(\alpha-\lambda)/E$

$\rightarrow C = (1-\alpha)/(1-\lambda)$ & $E = (\alpha-\lambda)/(1-\lambda)$

- Say, α = 20% & $1-\alpha$=80% & λ=10%: given the global warming externality , we should only be spending 11% of our ressources on energy rather than 20%); i.e. the size of the energy sector should be divided by about 2

- **How to implement the social optimum?**
- The corrective tax tE on energy consumption should finance a lump-sum transfer eaxctly equal to tE:
- Max U(c,e,E) under c+pe<y (with : p =1+t & y =1+tE)

  → $c = (1-\alpha)y$ & $e = \alpha y/p$

  → Optimal corrective tax is such that the fraction of resources spent on energy is the same as in the social optimum:

$$e/y = \alpha/p = (\alpha-\lambda)/(1-\lambda)$$

- I.e. $p = 1+t = \alpha(1-\lambda)/(\alpha-\lambda)$
- I.e. one introduces a tax so as to raise the relative price of energy and induce private agents to choose the socially optimal quantity of energy
- If $\lambda \to \alpha$ (i.e. negative externality almost as large as the benefits of energy), then $p \to \infty$ (infinite tax)
- If $\lambda > \alpha$, then energy should be banned
- **Transfer must be lump-sum, not proportional to e_i …**

- Assume $\alpha = 20\%$ & $1-\alpha=80\%$ & $\lambda=10\%$
- Then $p = 1+t = \alpha(1-\lambda)/(\alpha-\lambda) = 180\%$
- I.e. we need a tax rate $t=80\%$ to correct the global warming externality
- In effect, consumers pay their energy 80% higher than production costs; they keep spending 20% of their budget on energy, but 80%/180% = 45% of these spendings are paid to the government in energy taxes; i.e. 9% of national income goes into energy taxes, and everybody receives a green dividend equals to 9% of national income; in effect, the size of the energy sector is divided by almost two

Controversies about carbon taxes

- If we all agree about λ (utility cost of global warming), then we should also agree about the optimal carbon tax rate: $1+t = \alpha(1-\lambda)/(\alpha-\lambda)$
- Conversely, differences in perceptions about λ (=highly uncertain) can explain different levels of energy & environmental taxes in the EU (see Eurostat tables)
- Also there are other negative external effects to take into account: air quality, trafic congestion, etc.
- In the French 2008 carbon tax debate, the implicit assumption was that existing oil taxes correct for other externalities, and that the new carbon tax must deal with global warming: price of the carbon ton = estimate of the negative welfare impact of an additional ton of carbon emission: see Quinet Report 2008

The discount rate controversy

- Stern Report on the economic costs of global warming [Stern 2006 Report]
- An important part of the controversy was due to differences in the social discount rate
- I.e. assume that we agree that global warming will cause catastrophies that are equivalent to a loss equal to λ% of world GDP in T years
- Say λ=10%, and T=70 years (sea will rise around 2080)
- Q.: How much welfare should we ready to sacrifice today in order to avoid this? Should we stop using cars entirely?
- A.: We should be able to sacrifice $\mu Y_0 = e^{-r^*T} \lambda Y_T$, with r* = social discount rate = rate at which an ideal social planner should discount the future
- Q.: How should we choose r* ? r*≈0 or r*>>0 ?

- A.: The choice of r* depends on how one views future growth prospects: are future generations going to be so rich and so productive that they will be able to clean up our pollution?

- « Modified Golden rule »: $r^* = \delta + \gamma g$

with δ = pure social rate of time preference

g = economy's growth rate: $Y_t = e^{gt} Y_0$

γ = concavity of social welfare function

- r* is the social discount rate that should be used by a planner maximizing $V = \int_{t>0} e^{-\delta t} U(c_t)$

with $U(c)=c^{1-\gamma}/_{(1-\gamma)}$ (i.e. $U'(c)=c^{-\gamma}$)

- $\gamma \geq 0$ measures the speed at which the marginal social utility of consumption goes to zero = how useful is it to have another i-phone if you already have 100 i-phones?

($\gamma=0$: linear utility $U(c)=c$; $\gamma=1$: log utility $U(c)=\log(c)$;

$\gamma>1$: utility function more concave than log function)

- Stern vs Nordhaus controversy: both agree with the MGR formula but disagree about parameter γ

- Stern 2006 : δ=0,1%, g=1,3%, γ=1, so r*=1,4%

  (see Stern 2006 report, chapter 2A)

- Nordhaus 2007: δ=0,1%, g=1,3%, γ=3, so r*=4,0%

  (see Nordhaus, "Critical Assumptions in the Stern Review on Climate Change", Science 2007; JEL 2007)

- Whether one adopts $r^*=1{,}4\%$ or $r^*=4{,}0\%$ (for a given growth rate $g=1{,}3\%$) makes a huge difference:
- We should spend: $\mu Y_0 = e^{-r^*T} \lambda Y_T$, i.e. $\mu = e^{-(r^*-g)T} \lambda$ (since $Y_T = e^{gt} Y_0$)
- According to Stern $r^*-g=0{,}1\%$, so with $T=70$, $e^{(r^*-g)T}=1{,}07$: it is worth spending about 9% of GDP in 2010 in order to avoid a 10% GDP loss in 2080: we need to reduce emissions right now & to finance large green investments
- But $e^{(r^*-g)T}=6{,}61$ according to Nordhaus ($r^*-g=2{,}7\%$): it is worth spending only 1,5% of GDP in 2010 in order to avoid a 10% GDP loss in 2080: don't worry too much, growth will clean up the mess
- ≈ EU vs US position

- Intuition behind MGR: $r^* = \delta + \gamma g$
- If g=0, then $r^*=\delta$: social rate of time preference
- From an ethical viewpoint, everybody agrees that δ should be close to 0%: it is difficult to justify why we should put a lower welfare weight on future generations
- Both Stern & Nordhaus pick δ=0,1% (Stern mentions estimates of meteorit crash: the probability that earth disappears is <0,1%/yr)

→ with zero growth, everybody agrees that $\mu \approx \lambda$

(of course, private rate of time preference – i.e. how private individuals behave in their own life – are a different matter: they can be a lot larger)

- With $g>0$, one has to compute the impact on social welfare of reducing consumption by $dc_T<0$ at time $t=T$ and raising it by $dc_0>0$ at time $t=0$:
- Social welfare: $V = \int_{t>0} e^{-\delta t} U(c_t)$

  with $U(c)=c^{1-\gamma}/_{(1-\gamma)}$ (i.e. $U'(c)=c^{-\gamma}$)
- $dV = U'(c_0)\, dc_0 + e^{-\delta t}\, U'(c_T)\, dc_T$
- $c_T = e^{gT} c_0 \rightarrow dV = 0$ iff $dc_0 = e^{-(\delta+\gamma g)t}\, dc_T$

  $\rightarrow$ MGR: $r^* = \delta + \gamma g$
- Intuition: γ very large means that extra consumption not so useful for future generations, because they will be very rich anyway $\rightarrow$ very large r^*, even if g is quite small and uncertain

- What is strange in this controversy is that both Stern and Norhaus take opposite sides on concavity parameter γ as compared to the parameters that they usually favor for cross-sectional redistribution purposes: Stern would usually favor high γ (high redistribution) and Nordhaus low γ (low redistribution)

- If future growth was certain (i.e. future generations will be more productive, whatever they do), then it might indeed make sense to have high γ or even infinite γ = Rawlsian objective: we should only care about maximizing the lowest welfare or consumption level, i.e. the level of the current generation

- Two pb with this intergenerational Rawlsian reasonning:
- (1) growth is endogenous: if we leave infinite pollution (or debt) to future generations, maybe g will not be so large
- (2) one-good models are not well suited to study these issues: in the long run the relative price of the environment might be infinite (i.e. if we all have 100 i-phones, but unbreathable air, maybe the relative value of having a little bit clean air will be quite large)

  See J. Sterner, "An Even Sterner Review: Introducing Relative Prices into the Discounting Debate", JEP 2008

  See also R. Guesnerie, "Calcul économique et développement durable", RE 2004 ; "Pour une politique climatique globale", Cepremap 2010